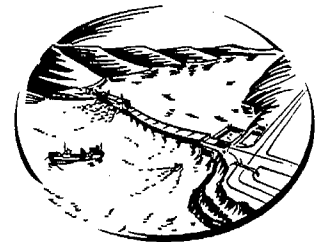


# 7. SALINITY

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## 7. SALINITY

### 7.1 SUMMARY

Over 130 miles of the main stem San Joaquin River is listed as water quality-impaired for salinity on the CWA's Section 303(d) list. Salt concentrations in this segment of the river impair the beneficial use of agricultural supply on a periodic basis.

Surface and subsurface agricultural drainage waters are the major source of salt in the lower San Joaquin River Basin. Agricultural drainage is also a source of salt in the Sacramento River. Salt loading leads to impairment of water quality in the lower San Joaquin River and in the Delta Region. Processes that affect salinity of water in a basin occur over short and long periods because of the interactions of surface and subsurface water and soil salinity.

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Salt loading leads to impairment of water quality in the lower San Joaquin River and in the Delta Region.

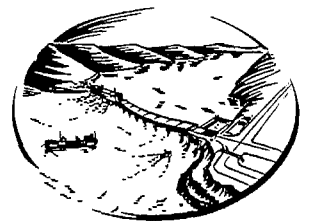
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The length of time over which a process occurs determines the sustainability (or durability) of the solution approach. Therefore, time is an important consideration in identifying the best solution approach. The CALFED Program principles mandate durable solution approaches that allow productive land use concurrent with reductions in salinity and selenium discharges to the environment.

The listed approaches, in various forms, have been studied and partially implemented over many years. Current technology for reverse osmosis and cogeneration is expensive, making these approaches less likely to be implemented over the short term. Source control, reuse, and integrated on-farm drainage management programs could be expanded immediately.

Much that can be achieved strictly through source control (exclusive of land retirement) and cycling or blending reuse already has been achieved; additional increased short-term load reductions likely will come at the expense of long-term increases in salt buildup in the San Joaquin River Basin (and associated increases in long-term loading to the San Joaquin River). These measures could continue to be used as a short-term solution for decreasing salt loads in the Delta, although drainage volumes and salt loads may increase in normal water years following dry years. Salt concentrations in shallow groundwater areas (0–10 feet) remained mostly constant from 1990 to 1994, but increased between 1994 and 1997.

Integrated on-farm drainage management, including sequential water reuse and solar evaporators, has more potential for success. Salt marketing of residual salts



depends on the quality of salts produced and the price of salt. The price will need to compete with abundant local and foreign markets.

Basinwide real-time management approaches can be promoted by districts through internal district policies. The CVRWQCB can also use its regulatory authority to encourage the districts or dischargers to promote these policies. Use of incentives, such as grants and low-interest loans for drainage reuse, drainage reduction, and improved irrigation efficiency, should be considered.

Proposed solution approaches involving DMC recirculation require coordination among government agencies, local districts, farmers, and other stakeholders. Many outstanding technical issues still surround the proposed DMC recirculation. Use of memoranda of understanding (MOU) and formation of working groups such as the San Joaquin River Management Program - Water Quality Subcommittee (SJRMWQS) (comprised of CRWQCB, Reclamation, DWR and Lawrence Berkeley National Laboratory [LBNL]) are recommended to gain user acceptance.

CALFED funding may be a significant source of funding for these proposed water quality actions. Government agencies, districts, and other stakeholders possess technical expertise and other resources needed to accomplish the actions. Existing programs both at the government and local level are important institutional resources that need to be utilized to the maximum extent.

None of the actions proposed here are expected to entirely solve the salinity problems. However, the combination of local-level actions and basinwide approaches will improve water quality to a large degree.

## 7.2 PROBLEM STATEMENT

Portions of rivers and the Delta are impaired by discharges from agriculture, wetlands, mines, industries, and urban areas. Significant amounts of TDS enter the rivers and the Delta from these sources. Natural tidal fluctuation (and resulting intrusion of sea water) is a major source of salinity in the Delta. Salinity primarily affects agricultural and drinking water beneficial uses of water.

Water intakes for drinking water and agricultural water supply in the CALFED study area have locally and seasonally elevated salt concentrations in excess of water quality objectives established to protect beneficial uses. Fish and wildlife also can be affected by locally and seasonally elevated salinity, with a potential for even more sensitivity due to specific ion toxicity. Seasonal and site-specific objectives for salt routinely are exceeded in some regions.

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Water intakes for drinking water and agricultural water supply in the CALFED study area have locally and seasonally elevated salt concentrations in excess of water quality objectives established to protect beneficial uses.

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Salinity in Delta export supplies is highly variable. When salinity is high, considerable impacts on local water management programs, such as groundwater conjunctive use and water recycling, occur. Impacts due to high salinity may result in local users abandoning such programs and reverting to imported supplies. Further, low-salinity SWP water is essential for blending purposes to extend the benefits of local water management programs.

The quality of source waters for various discharges must be considered. Supply water in the San Joaquin River watershed generally is higher in salts than supply water in the Sacramento River watershed. Salt loads from similar sources in different watersheds will, therefore, vary greatly because of the variability in the initial base salt load of the water supply. Some sources substantially discharge to land. Although such discharges will not immediately affect surface water quality, salt loading of groundwater may result in significant future effects.

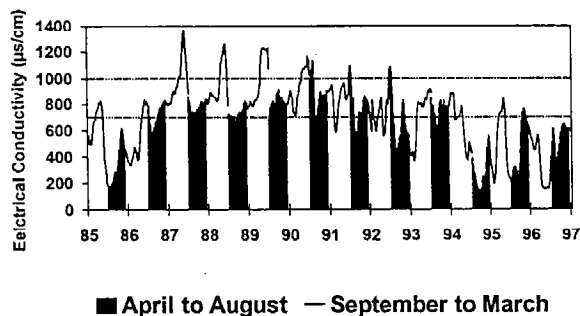
The salt concentrations of water in the lower San Joaquin River and south Delta frequently exceed desirable levels for agricultural beneficial uses. The 700-microsiemens-per-centimeter ( $-\mu\text{s}/\text{cm}$ ) 30-day running average specific conductance (or electrical conductivity) water quality objective for the San Joaquin River near Vernalis for the April to August period has been exceeded 54% of the time from 1986 through 1997 (Figure 12). The 1,000- $\mu\text{s}/\text{cm}$  water quality objective for the September to March period has been exceeded 13% of the time. These rates of exceedance are higher than has been estimated for longer periods (using model studies) because of the high frequency of critically dry years between 1986 and 1997.

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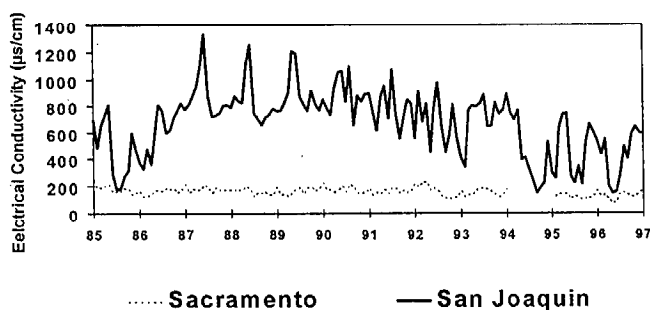
The salt concentrations of water in the lower San Joaquin River and south Delta frequently exceed desirable levels for agricultural beneficial uses.

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Although agricultural drainage can be a major source of wastewater in the Sacramento River, the generally higher quality of supply water and higher river flows result in relatively little adverse impact on Sacramento River water quality. Water in the lower Sacramento River (at Freeport) is of much higher quality compared to the San Joaquin River (near Vernalis). The 340- $\mu\text{s}/\text{cm}$  CVRWQCB objective for the Sacramento River at the I Street Bridge was not exceeded between water years 1986 and 1997. Figure 13 compares the water quality of the Sacramento and San Joaquin Rivers.



**Figure 12. San Joaquin River near Vernalis 30-Day Running Average Electrical Conductivity**



**Figure 13. Comparison of Sacramento and San Joaquin River Water Quality**

## 7.3 OBJECTIVE

The primary objective is to reduce or manage salinity in the San Joaquin River and in the Delta Region to meet water quality objectives and protect beneficial uses by such means as relocating points of drainage discharge, improving flow patterns using flow barriers, reducing and managing drainage water, reducing salts discharged to these water bodies, real-time management, and using the assimilative capacity of the river through the DMC circulation. Currently, the timing of the discharges of drainage from the Grassland area is not coordinated with

reservoir releases; consequently, the assimilative capacity of the San Joaquin River is frequently exceeded at the point of discharge and at Vernalis.

Protection of existing beneficial uses can be accomplished over the short term through a variety of solution approaches, but many of these approaches have limited long-term sustainability. An important secondary objective, therefore, is to implement solution approaches that do not adversely affect water quality in the San Joaquin River over the long term. It is not sufficient to consider short-term improvement of water quality in the San Joaquin River or the Delta as an assessment endpoint because such an assessment may ignore the long-term ability of sustaining such an improvement. The desired goal therefore must include the more complexly defined ability to achieve water quality objectives to protect beneficial uses and to meet those water quality objectives over the long term.

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Protection of existing beneficial uses can be accomplished over the short term through a variety of solution approaches, but many of these approaches have limited long-term sustainability.

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## 7.4 PROBLEM DESCRIPTION

### 7.4.1 *Lower San Joaquin River Basin Salt Balance*

Salt balance is discussed here in the context of the lower San Joaquin River Basin because of the significant import of salt into the basin. No such import occurs in the Sacramento River Basin, except capture of high-quality water from adjacent watersheds. Water imports into the San Joaquin River Basin have high salt concentrations and loads because the water source is the Delta. Intake to the DMC is a mix of San Joaquin and Sacramento River water. In the absence of barriers in the south Delta, the San Joaquin River has, at times, provided the majority of the water exported back into the San Joaquin Valley, leading to a short- to long-term recycling of salts in the San Joaquin Valley. Solution approaches that do not consider salt balance in the San Joaquin Valley generally will have limited success over longer time periods.

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Water imports into the San Joaquin River Basin have high salt concentrations and loads because the water source is the Delta.

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Approximately 600,000 tons of salt per year, on average, were imported into the DMC service area on the west side of the San Joaquin River via the DMC between 1985 and 1994. Another 160,000 tons per year, on average, were imported into the west side via diversions from the San Joaquin River. Dissolution of in-situ salts averaged 250,000 tons per year for the same period, resulting in gross salt import and salt dissolution of 1,010,000 tons per year on the west side of the San Joaquin River north of the Mendota Pool. Mean annual salt exported out of the basin was approximately 770,000 tons per year, which includes 150,000 tons per year from tributaries on the east side of the San Joaquin River. The net discharge of salt from the west side of the San Joaquin River is

620,000 tons per year, suggesting an increase of 390,000 tons per year. This leads to increasing salt loading to the San Joaquin River via groundwater accretions. The 1985-1994 period for which data were available included an unusual number of dry years and, therefore, may not be representative of general conditions.

### 7.4.2 Local Actions

Surface agricultural runoff and subsurface agricultural drainage are the major sources of salt in the lower San Joaquin River Basin. Salt loading from agricultural drainage in the San Joaquin River leads to impairment of water quality in the lower San Joaquin River and south Delta. Surface agricultural runoff is also a significant source of salt in the Sacramento River, but salt concentrations of agricultural discharges in the Sacramento River watershed are substantially lower than in the San Joaquin River watershed. This, in part, is due to agricultural supply water of better quality (lower salinity) in the Sacramento River watershed than in the San Joaquin River watershed. Sacramento River flows are also generally much higher than the San Joaquin River, providing greater dilution flows and lower salt concentrations. Although the Sacramento River may have locally acceptable salt concentrations, increased background loads of salt in the Sacramento River make it a less effective source of dilution water for the much more saline San Joaquin River when mixed in the Delta.

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Surface agricultural runoff and subsurface agricultural drainage are the major sources of salt in the lower San Joaquin River Basin. Salt loading from agricultural drainage in the San Joaquin River leads to impairment of water quality in the lower San Joaquin River and south Delta.

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### 7.4.3 Sources

Surface agricultural runoff contributes a large load of salt to the San Joaquin and Sacramento Rivers, although at low concentrations relative to subsurface agricultural runoff. Surface agricultural runoff flows contribute salt load to the San Joaquin and Sacramento Rivers throughout the basins, compared with subsurface drainage with a much more limited areal extent (mostly in the San Joaquin River Basin). Salt in supply water can represent a large proportion of the salt in surface agricultural runoff. Irrigation supply water quality is therefore a critical factor in determining surface agricultural runoff water quality. In areas where water conservation measures (such as on-farm recycling) are used, surface agricultural runoff will, in general, be more saline than in areas using no recycling. Although a lower volume of water may be discharged through the use of conservation and recycling measures, remaining surface and subsurface drainage will contain elevated salt concentrations.

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Salt in supply water can represent a large proportion of the salt in surface agricultural runoff.

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Application of water in excess of leaching requirements leads to both increased surface agricultural runoff and increased salt leaching from the root zone. This excess salt leaching results in short- to moderate-term loading of salt to

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Application of water in excess of leaching requirements leads to both increased surface agricultural runoff and increased salt leaching from the root zone.

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groundwater and ultimately in indirect, long-term loading via groundwater accretions to surface waters if the salt is not removed. Surface agricultural runoff can result in additional adverse impacts due to other constituents of concern (see the "Pesticides" section). Although it is an important source of salt, surface agricultural runoff also may provide the majority of flow in the San Joaquin River upstream of the major east side tributaries during low-flow periods. Surface agricultural runoff may at times exceed existing water quality objectives but still provide dilution flow relative to subsurface drainage and groundwater accretions.

Subsurface drainage is a much more concentrated source of salt than surface agricultural runoff. Subsurface drainage from specific geographic areas, such as the drainage problem area of the Grassland watershed in the San Joaquin River Basin, also are associated with adverse impacts related to selenium. High salinity in irrigation supply water can increase the need for additional water to leach imported and in-situ salts.

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Subsurface drainage is a much more concentrated source of salt than surface agricultural runoff.

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#### **7.4.4 Impacts**

Elevated salinity in the San Joaquin River leads to frequent exceedance at the Airport Way Bridge near Vernalis of existing water quality objectives for the San Joaquin River. Objectives for the San Joaquin River were established by the SWRCB to protect agricultural beneficial uses in the south Delta (Figure 6). These elevated salt concentrations also impair water quality exported from the Delta for agricultural, municipal, and industrial uses. Salinity is important to agriculture because in elevated concentrations it harms crops. Salinity also reduces the ability to reuse irrigation water and, thus, conserve fresh-water supplies. Salt in drinking water supplies is important because it can reduce the useful life of water systems and water-using equipment and appliances. Also, especially in Southern California where water supplies are blended, salt reduces the ability to stretch water supplies. In addition, high-salinity water is much less useful for water recycling, thus further inhibiting the ability to use water efficiently.

Fish and wildlife also can be affected by locally and seasonally elevated salinity levels. Frequent releases currently are made from New Melones Reservoir on the Stanislaus River exclusively to provide dilution flows in the San Joaquin River that are required to meet established water quality objectives. Current Basin Plan amendment work by the CVRWQCB likely will result in the geographic expansion of salinity water quality objectives in the San Joaquin River Basin. Seasonal environmental impacts to the environment can be related both to salinity and specific ion toxicity to some species.

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Fish and wildlife also can be affected by locally and seasonally elevated salinity levels.

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## 7.5 APPROACH TO SOLUTIONS

### 7.5.1 Local Actions

Local actions discussed below include source control and drainage reduction, reuse, reverse osmosis, cogeneration, and integrated on-farm drainage management.

#### *Priority Actions*

##### *Source Control and Drainage Reduction*

Agricultural drainage water volume could be reduced through reduction or elimination of unnecessary deep percolation that results from application of irrigation water in excess of leaching requirements and through the sequential reuse of drainage water on selected crops grown in the area. Salt application to the irrigated lands of the San Joaquin River Basin also could be reduced through conservation measures. The San Joaquin Valley Drainage Program (SJVDP) identified the most effective means of achieving higher irrigation efficiencies:

- Improving management of irrigation systems;
- Adopting new or improving existing irrigation practices, including shortening furrows and installing tailwater return systems; and
- Improving irrigation scheduling.

Further, higher irrigation efficiency also can be achieved by sequentially reusing drainage water to irrigate salt-tolerant crops.

Adequate data are available from the large body of work performed by the SJVDP and UC Salinity/Drainage Program to evaluate the feasibility and effectiveness of these methods. Ongoing work of the SJVDP, UC Salinity/Drainage Program, San Joaquin River Management Program (San Joaquin River MP), and the Grassland Bypass Project has added to this knowledge base. Considerable data exist on drainage water management in the San Joaquin River Basin. Data on irrigation efficiencies in the Grassland area have been published by the districts, the CVRWQCB, and others. Published data indicate that irrigation efficiencies have

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Agricultural drainage water volume could be reduced through reduction or elimination of unnecessary deep percolation that results from application of irrigation water in excess of leaching requirements and through the sequential reuse of drainage water on selected crops grown in the area.

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indicate that irrigation efficiencies have improved significantly since 1990. Irrigation efficiencies up to 75% have been reported.

Data are lacking on the irrigation efficiencies on the lands that are not tile drained. Less data are readily available for the Sacramento River watershed.

Additional reductions in loading for source control, drainage reduction, and reuse (further discussed below) can be achieved through the following methods:

- Prepare salt reduction plans for each source of TDS (prepare water conservation plans and drainage and wastewater operation plans).
- Provide incentives for water conservation and drainage water use.
- Improve irrigation methods, irrigation management, and sequential reuse of drainage water (to improve water use efficiency).
- Use sprinkler irrigation combined with furrow irrigation to reduce drainage volume.
- Use salt-tolerant crops in a farm cropping system.

For all methods, adequate leaching of salts is required to prevent salt accumulation in the soil profile. Irrigation improvements can be accomplished by better irrigation technology, and water management can be encouraged by availability of low-interest loans to districts.

These actions could be encouraged by water districts (continued education and implementation of BMPs) and larger entities, such as the Grassland Area Drainers coordination of subsurface drainage as part of the Grassland Bypass Project. The promotion of on-farm salt management systems would significantly help to achieve these goals. The CVRWQCB could use its regulatory authority to require implementation of these actions (use of drainage operation plans). Establishment of water quality objectives upstream on the main stem San Joaquin River or development of TMDL allocations for affected water bodies would provide regulatory incentive for implementation of these actions. Use of incentives such as grants, low-interest loans for drainage reuse, tiered water pricing, and establishment of demonstration projects should be considered. CALFED should support establishment of water quality objectives upstream of Vernalis, development and implementation of BMPs, development of TMDLs, and financial incentives for salt control.

Existing institutional opportunities (such as district policies, agreements, MOUs, MAAs, ordinances, planning process, and technical assistance) must be used. The

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Irrigation improvements can be accomplished by better irrigation technology, and water management can be encouraged by the availability of low-interest loans to districts.

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